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Schoolroom Motivation: II. Two Studies of Quantity and Pattern of Verbal Reinforcement as Related to a Measure of Drive on a Routine Task

by
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CHAPTER I

THE PROBLEM

In 1954 and 1955 two experiments were carried out to discover how elementary school pupils react to positive verbal stimuli (specifically, verbal reinforcement or praise) from their regular classroom teachers. The two experiments were identical in design, except that the first dealt with the effects of verbal reinforcement under massed practice, while the second dealt with the effects of verbal reinforcement under spaced practice. The intertrial interval under the first of these conditions was essentially zero, whereas there was an interval of some 24 hours under the second.

The initial measure chosen for changes in pupil behavior dependent upon variations in the schedule of verbal reinforcement was performance on a routine non-verbal task. The techniques relative to the routine task and the verbal reinforcement were similar to those described by Hurlock (10)* in an earlier study, and to those employed by Auble, Mech, et al. (1, 2, 3, 4, 5, 12, 13) in a series of exploratory studies preceding the experiments under discussion. These techniques have been fully described in a recent report by the present authors concerning the relation of quantity and pattern of verbal reinforcement to performance on a routine task in a classroom situation (11).

Four major conclusions were drawn on the basis of the statistical analyses presented in that report. First, a given quantity of verbal reinforcement administered to pupils of varying intelligence levels fails to produce differential effects related to intelligence upon performance on a routine arithmetical task, providing initial performance is taken into account. Second, a given quantity of verbal reinforcement produces differential effects upon performance on a routine arithmetical task when it is administerd variously on a fixed periodic schedule and on a predetermined random schedule. Third, varying quantities of verbal reinforcement produce highly significant differential effects upon performance on a routine arithmetical task. (The observed differences were not sufficiently systematic to permit determination of an optimum level of reinforcement.) Fourth, though the specific results do not coincide entirely, the foregoing conclusions are valid both for procedures utilizing massed practice and for procedures utilizing spaced practice.

It must, however, be recognized that performance, as measured by the number of correct responses, is not necessarily the best measure of the motivation induced by verbal reinforcement. For situations leading to a number of divergent response tendencies, including only a single correct one,

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*Numbers in parentheses refer to references listed numerically in the bibliography.

Hullian drive theory (9) recognizes that higher drive levels do not always lead to superior performance, in the sense defined above.

In what follows, therefore, it is proposed to examine the data of the two experiments with a view to answering the following questions:

1. Do varying quantities of verbal reinforcement, as defined for these studies, exert differential effects upon the drive level of pupils, as measured by the gross number of responses on a routine task in the course of one trial?

2. Does the presence or absence of a regular, cyclic pattern of reinforcement exert differential effects upon the effectiveness of a fixed quantity of verbal reinforcement?

3. Does a fixed quantity of verbal reinforcement exert differential effects upon the drive level (as defined in Question 1, above) of pupils of varying intelligence levels?

4. To what extent do results obtained under massed practice correspond to those obtained under spaced practice?

5. To what extent does the effect of verbal reinforcement upon drive level, as measured by the gross number of responses on a routine task, correspond to its effect on performance on a routine task, as measured by the number of correct responses?

The authors wish to state again that they do not subscribe to the notion that the motivation of pupils can be explained solely in terms of verbal stimuli emitted by the teacher. Nevertheless, these incentives constitute one manipulable aspect of motivation, and their role in determining the motivation, or the drive level, of pupils may therefore be determined by the application of methods such as those employed in the present experiments.

CHAPTER II

METHODOLOGY[1]

The Variables

The principal independent variable in the present experiments is the quantity of verbal reinforcement administered by the classroom teacher to the pupils in the class. This variable is a discrete one, taking on only five distinct values: 100%, 75%, 50%, 25% and 0%, where the figures denote the proportion of trials after which the total group is reinforced.

The other independent variable is the pattern of verbal reinforcement, which assumes only two discrete values: periodic and random. Under periodic reinforcement the indicated proportion of reinforcement is delivered according to a fixed cyclic pattern throughout the experiment. In the case of the corresponding random reinforcement, verbal reinforcement is delivered after the same number of trials in the course of the experiment, but these trials are randomly selected. Clearly, the periodic and random patterns of reinforcement coincide in the case of the 100% and 0% reinforcement groups.

The variable dependent on the foregoing independent variables is the drive level of the pupils when confronted by a routine arithmetical task. For the purposes of the present study, drive level is defined to be measured by the gross number of responses (correct and incorrect) per trial.

A further variable, which can be called neither dependent nor independent, but should rather be identified as a criterion of classification, is the intelligence level of the subjects. The measures of intelligence employed were the Otis Intelligence Test and the California Test of Mental Maturity, but all subjects under any given experimental condition had the same measure. The intelligence quotients for all subjects were drawn from the cumulative school records. Subjects were then divided into "high," "medium," and "low" intelligence groups on the basis of these intelligence quotients, as follows: high, 110 or more; medium, 90-109; low, 89 or less. One reason for this choice of boundaries for the intelligence groups lies in certain considerations of comparability between the two different measures of intelligence that had to be used.

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[1] A detailed description of all aspects of the design and procedure of the experiments will be found in the report, already cited, of the results concerning the relation of quantity and pattern of reinforcement to performance on a routine task in a classroom situation (11). Some of the details of the methodology have therefore been omitted from this chapter.

The Subjects

The subjects used in these experiments were third grade and fourth grade pupils drawn from the elementary school systems of Martinsville and Columbus, Indiana.

Each experiment involved five third grade classrooms and five fourth grade classrooms, a total of 20 classrooms for both studies. The assignment of these classrooms to the various experimental groups is indicated in Table 1.

A subject was included in the final tabulation and analysis of the data only if at least the following data were available for him: (a) a measure of I.Q., (b) at least two of the three pretest trials, and (c) at least 22 of the 28 experimental trials, with no four consecutive trials missing.

TABLE 1. SCHEDULES AND GRADE LEVELS OF THE EXPERIMENTAL GROUPS

Group	Reinforcement schedule		Grade-level
	Quantity	Pattern	
A_1	100%	Periodic-random	4
A_2	100%	Periodic-random	3
B_1	75%	Periodic	4
B_2	75%	Random	4
C_1	50%	Periodic	3
C_2	50%	Random	4
D_1	25%	Periodic	3
D_2	25%	Random	3
E_1	0%	Periodic-random	4
E_2	0%	Periodic-random	3

This criterion yielded 325 complete sets of data for the experiment involving massed practice, and 284 sets for the experiment involving spaced practice.

The Task

The routine arithmetical task confronting the subjects on each trial consisted of a set of additions and subtractions. Each set consisted of two pages of problems, each page of nine rows, and each row of eight problems. There were thus 144 problems, correct solution of all of which within the four-minute time limit would clearly be impossible for any third or fourth grade pupil. However, though the maximum number of

correct responses for any single trial was less than 100, a number of subjects attempted all 144 problems on some trials. Careful inspection of the data shows that these subjects invariably belonged to the low intelligence subgroups, and that their answers were simply one- and two-digit numbers written down apparently at random.

All problems involved the addition or subtraction of pairs of numbers of two digits at most. Both the numbers and the operations were selected with the aid of a table of random integers, subject only to the limitation that each page of 72 problems should contain 36 addition problems and 36 subtraction problems. Five forms of such sets of problems were prepared, and they were administered to the subjects in cyclic order.

The Procedure

Each experiment consisted of three pretest trials (which provided a measure of each pupil's initial drive level on the experimental task) and of 28 experimental trials. Each trial was of precisely four minutes' duration.

In the case of the experiment dealing with massed practice, the pretest trials were administered on the afternoon of the first day of the experiments. The experimental trials were administered on the morning of the second day. The interval between trials sufficed merely to administer the verbal reinforcement, if any, and to prepare for the next trial. There was a rest interval of approximately 10 minutes after the fourteenth experimental trial.

The experiment dealing with spaced practice extended over a period of eight weeks. The pretest trials were administered during the first three days of the first week, and were followed by an interval of one and one-half weeks. The experimental trials, which were administered at the rate of one per day, about mid-morning, from Monday to Friday, began on Monday during the third week. No trial was administered on Friday of the fifth week (after the fourteenth experimental trial) in order to provide a longer interval corresponding to the rest interval allowed at that stage during the experiment dealing with massed practice.

The classroom teachers were provided with complete sets of instructions to enable them to conduct the experiment in their own classrooms. The experimenters did not at any time enter any of the classrooms.

The teachers were requested to avoid delivering reinforcement in any form during the pretest trials and to remain stationary at the front of the room. During the experimental trials, however, all of the teachers were required to move about the room constantly, pretending to note how each pupil was performing.

If verbal reinforcement was scheduled after a given trial, the teacher was requested to convey the following four points in her own words, as was the case with all the experimental instructions: (a) "You all did very well this time." (b) "I (the teacher) am very pleased." (c) "Now, try to do even better on the next set of problems." (d) "Work as fast as you can, but try not to make any mistakes."

The Analysis

The statistical technique employed to analyze the data resulting from these experiments was the analysis of covariance with a single criterion of classification--the experimental condition. The pretest and experimental measures have already been described. Though the groups were of necessity unequal in size, the usual technique of covariance analysis, as described by Snedecor (15), was employed as being the least likely to produce biased results.

The analyses of the two sets of experimental data proceed exactly parallel, through the following three steps:

1. An analysis for the differential effects of a fixed quantity of verbal reinforcement upon the drive level of subjects of varying intelligence levels.

2. An analysis for the differential effects upon the drive level of all subjects of a fixed quantity of verbal reinforcement administered according to varying patterns.

3. An analysis for the differential effects upon the drive level of all subjects of varying quantities of verbal reinforcement.

It has been pointed out in connection with the use of the mean number of correct responses per trial as the measure of the dependent variable that no comparison is possible between the data obtained under massed practice and the data obtained under spaced practice, because the subjects participating in the experiment utilizing spaced practice were learning arithmetic continuously during the eight weeks spanned by the study.

It appears to the authors that the same argument must preclude such a comparison even when the measure of the dependent variable is the mean gross number of responses per trial, because it is not possible to assume that increased competence in the basic skills required by the experimental task will exert no effect upon a subject's drive level toward the experimental task.

Relationships Between Measures of Performance and Drive

Before substitution of a measure of drive[2] for one of performance in the analysis of the two experiments may be considered justified, there should be some evidence that the two measures are not connected by a linear relation that is uniform in all experimental groups.

Table 2 presents the coefficients of correlation between the measures of drive and performance for the subgroups of differing intelligence levels of each experimental group under massed reinforcement. Also presented are the coefficients of regression of the measure of drive upon that of performance.

TABLE 2. COEFFICIENTS OF CORRELATION BETWEEN THE MEASURES OF DRIVE AND PERFORMANCE FOR THE GROUPS RECEIVING MASSED REINFORCEMENT*

Intelligence level	100%	75%	50%	25%	0%
High	0.81 (0.75)*	0.97 (1.04)	1.00 (0.96)	0.97 (0.91)	1.00 (0.96)
Medium	0.76 (0.78)	0.98 (1.01)	0.76 (0.78)	0.54 (0.56)	0.64 (0.56)
Low	-0.23 (-0.38)	-0.12 (-0.16)	0.92 (0.88)	0.67 (0.53)	0.30 (0.25)

*All correlation coefficients computed to three decimal places and rounded off.

*Coefficients of regression of the measure of drive upon that of performance are given in parentheses.

All correlations except those for the low intelligence subgroups of the 100%, 75%, and 0% groups are significant at

[2] The measure of drive used here, the mean gross number of responses per trial throughout the experiment, is found to be very closely related to a similar mean over only the last four experimental trials. Coefficients of correlation computed for the subgroups of varying intelligence levels of all experimental groups in both studies ranged from 0.84 to 1.00 (rounded value), with a median of 0.93.

the 0.01 level (median r = 0.76), but inspection of the regression coefficients shows the wide variation in the nature of the relationship in the various experimental groups. Whereas the regression coefficients for the high intelligence subgroups are positive and close to unity, those for the low intelligence subgroups range from -0.38 to 0.88, with a median of 0.25. Thus, although a highly significant linear relationship is seen to exist between the measures of drive and performance in almost all of the experimental subgroups, this relationship is not uniform, and the results of the analyses utilizing the two measures need not coincide simply due to a lack of differentiation between the measures.

Table 3 presents the coefficients of correlation between the measures of drive and performance, and the coefficients of regression of the measure of drive upon that of performance, for the various subgroups in the experiment involving spaced practice.

TABLE 3. COEFFICIENTS OF CORRELATION BETWEEN THE MEASURES OF DRIVE AND PERFORMANCE FOR THE GROUPS RECEIVING SPACED REINFORCEMENT*

Intelligence level	100%	75%	50%	25%	0%
High	1.00 (0.93)**	0.89 (0.92)	0.98 (0.88)	-0.14 (-0.08)	0.99 (0.97)
Medium	0.91 (0.77)	0.95 (0.88)	0.81 (0.73)	0.13 (0.15)	0.91 (0.87)
Low	0.62 (0.79)	0.70 (0.91)	-0.09 (-0.10)	0.03 (0.05)	0.81 (0.99)

*All correlation coefficients computed to three decimal places and rounded off.

**Coefficients of regression of the measure of drive upon that of performance are given in parentheses.

All correlation coefficients except those for the subgroups of the 25% reinforcement group and for the low intelligence subgroup of the 50% reinforcement group are highly significant (median r = 0.81), but a considerable variation among regression coefficients is still evident. Although this variation is not as systematic as in the study involving massed practice, the conclusion drawn there may nevertheless be extended to the case of spaced practice.

CHAPTER III

EXPERIMENT ONE: MASSED PRACTICE

Verbal Reinforcement and Intelligence

As stated, the subjects in each reinforcement group were divided into "high," "medium," and "low" intelligence subgroups according to whether their intelligence quotients (as measured by the Otis Intelligence Test or the California Test of Mental Maturity) were 110 or more, between 90 and 109, or 89 or less, respectively.

In seeking a relationship between the effects of varying quantities of verbal reinforcement upon the drive level of the subjects in a classroom situation and the intelligence level of the subjects, the hypothesis tested is essentially that a fixed amount of verbal reinforcement exerts no differential effects upon the drive level of subjects classified into three disjoint intelligence levels. It is not proposed to make any comparison between subgroups receiving differing quantities of verbal reinforcement.

Table 4 summarizes the analysis of covariance carried out to test for differences in drive level between the subgroups of high, medium, and low intelligence levels within the group receiving 100% reinforcement under massed practice. The obtained value of F was 3.62, which is significant at the 0.05 level of confidence for two degrees of freedom between groups and 61 degrees of freedom within groups.

TABLE 4. ANALYSIS OF COVARIANCE FOR DIFFERENCES IN DRIVE LEVEL BETWEEN SUBGROUPS OF VARYING INTELLIGENCE LEVELS WITHIN THE 100% MASSED REINFORCEMENT GROUP

Source of variation	d.f.	Sum of squares of adjusted scores	Mean square	F
Total	63	10,261.90		
Within groups	61	9,172.98	150.38	
Between adjusted means	2	1,088.92	544.46	3.62*

*Significant at the 0.05 level of confidence.

It must therefore be concluded that the effects on the drive level of subjects, as measured by their mean gross number of responses per trial, of 100% reinforcement under massed practice is related to their level of intelligence. Inspection of Table 5, which presents the pretest, experimental, and adjusted means for the three subgroups of varying intelligence levels within the 100% reinforcement group, shows that the adjusted mean for the high intelligence subgroup (24.38) was substantially lower than the corresponding mean for either the medium intelligence subgroup (31.17) or the low intelligence subgroup (35.86). Moreover, the mean gross number of responses per trial over the 28 experimental trials for the high intelligence subgroup was 24.50, whereas the corresponding figure over the three pretest trials was 28.98. With a single exception,[1] this is the only instance in either experiment of a decline in the gross number of responses between the pretest and experimental phases of the procedure.

TABLE 5. PRETEST, EXPERIMENTAL, AND ADJUSTED MEANS FOR THE THREE SUBGROUPS OF VARYING INTELLIGENCE LEVELS WITHIN THE 100% MASSED REINFORCEMENT GROUP

Intelligence level	n	Pretest mean	Experimental mean	Adjusted mean
High	16	28.98	24.50	24.38
Medium	33	23.14	28.26	31.17
Low	16	40.08	41.74	35.86

The result here obtained is, moreover, sharply at variance with the result of the corresponding analysis performed on the number of correct responses per trial made by the same subjects. In that instance, the obtained value of F was 0.29, and the null hypothesis was, of course, retained.

It appears, therefore, that 100% reinforcement administered under conditions of massed practice over 28 trials results in a significantly lower drive level (but not a lower level of performance) for subjects of high intelligence than for subjects of medium or low intelligence. The authors think it undesirable to conjecture about the explanation of such a result pending the availability of corroborative data.

[1] According to the observations of one of the experimenters, the experimental procedure was not adequately followed in the case of the group receiving 50% massed reinforcement on a periodic schedule. The pretest and experimental means for this group are 19.76 and 18.48, respectively.

A similar analysis of covariance, carried out to test for differences in drive level between the subgroups of varying intelligence levels within the 75% reinforcement group, is summarized in Table 6. The obtained value of F was 0.57, which fell far short of statistical significance. As in the case of all analyses involving the subgroups of varying intelligence levels of the partial reinforcement groups, the groups which received 75% reinforcement on periodic and random schedules were pooled.

TABLE 6. ANALYSIS OF COVARIANCE FOR DIFFERENCES IN DRIVE LEVEL BETWEEN SUBGROUPS OF VARYING INTELLIGENCE LEVELS WITHIN THE 75% MASSED REINFORCEMENT GROUP

Source of variation	d.f.	Sum of squares of adjusted scores	Mean square	F
Total	72	4,085.08		
Within groups	70	4,018.79	57.41	
Between adjusted means	2	66.29	33.15	0.57

The pretest, experimental, and adjusted means associated with the foregoing analysis are presented in Table 7.

TABLE 7. PRETEST, EXPERIMENTAL, AND ADJUSTED MEANS FOR THE THREE SUBGROUPS OF VARYING INTELLIGENCE LEVELS WITHIN THE 75% MASSED REINFORCEMENT GROUP

Intelligence level	n	Pretest mean	Experimental mean	Adjusted mean
High	11	20.12	23.71	29.07
Medium	48	27.13	33.41	31.49
Low	15	23.16	29.84	32.05

Table 8 summarizes the results of a similar analysis of covariance for differences in drive level between the high, medium, and low intelligence subgroups of the groups receiving 50% reinforcement. The obtained F-value of 0.16 is clearly not statistically significant.

TABLE 8. ANALYSIS OF COVARIANCE FOR DIFFERENCES IN DRIVE LEVEL BETWEEN SUBGROUPS OF VARYING INTELLIGENCE LEVELS WITHIN THE 50% MASSED REINFORCEMENT GROUP

Source of variation	d.f.	Sum of squares of adjusted scores	Mean square	F
Total	61	1,656.31		
Within groups	59	1,647.17	27.92	
Between adjusted means	2	9.14	4.57	0.16

Table 9 presents the pretest, experimental, and adjusted means for the three subgroups of the 50% reinforcement group involved in the preceding analysis.

TABLE 9. PRETEST, EXPERIMENTAL, AND ADJUSTED MEANS FOR THE THREE SUBGROUPS OF VARYING INTELLIGENCE LEVELS WITHIN THE 50% MASSED REINFORCEMENT GROUP

Intelligence level	n	Pretest mean	Experimental mean	Adjusted mean
High	19	20.49	20.81	23.44
Medium	34	24.98	25.08	23.14
Low	10	21.50	22.61	24.22

The corresponding covariance analysis for differences between the subgroups of the 25% reinforcement group is summarized in Table 10. The obtained F-value was 0.86, which clearly falls considerably short of statistical significance.

The pretest, experimental, and adjusted means for the three subgroups of varying intelligence levels within the 25% reinforcement group are presented in Table 11.

Table 12 summarizes the results of the covariance analysis carried out to test for differences in drive level between the high, medium, and low intelligence subgroups within the 0% reinforcement group. Though there was no reinforcement in this case to exert a differential effect upon these subgroups of varying intelligence levels, it is necessary for the proper interpretation of the foregoing results to know whether

significantly different changes in drive level occurred in these subgroups simply as a result of the experimental procedure.

TABLE 10. ANALYSIS OF COVARIANCE FOR DIFFERENCES IN DRIVE LEVEL BETWEEN SUBGROUPS OF VARYING INTELLIGENCE LEVELS WITHIN THE 25% MASSED REINFORCEMENT GROUP

Source of variation	d.f.	Sum of squares of adjusted scores	Mean square	F
Total	66	2,564.64		
Within groups	64	2,497.53	39.02	
Between adjusted means	2	67.11	33.56	0.86

TABLE 11. PRETEST, EXPERIMENTAL, AND ADJUSTED MEANS FOR THE THREE SUBGROUPS OF VARYING INTELLIGENCE LEVELS WITHIN THE 25% MASSED REINFORCEMENT GROUP

Intelligence level	n	Pretest mean	Experimental mean	Adjusted mean
High	12	19.33	21.95	21.29
Medium	36	16.93	18.34	19.10
Low	20	19.85	21.86	20.89

TABLE 12. ANALYSIS OF COVARIANCE FOR DIFFERENCES IN DRIVE LEVEL BETWEEN SUBGROUPS OF VARYING INTELLIGENCE LEVELS WITHIN THE 0% MASSED REINFORCEMENT GROUP

Source of variation	d.f.	Sum of squares of adjusted scores	Mean square	F
Total	53	1,752.63		
Within groups	51	1,715.93	33.65	
Between adjusted means	2	36.70	18.35	0.55

The obtained F-value being 0.55, there are no significant differences in drive level between the subgroups of the 0% reinforcement group. Table 13 presents the pretest, experimental, and adjusted means associated with the foregoing analysis.

TABLE 13. PRETEST, EXPERIMENTAL, AND ADJUSTED MEANS FOR THE THREE SUBGROUPS OF VARYING INTELLIGENCE LEVELS WITHIN THE 0% MASSED REINFORCEMENT GROUP

Intelligence level	n	Pretest mean	Experimental mean	Adjusted mean
High	18	28.19	30.80	30.43
Medium	25	27.83	28.59	28.59
Low	12	27.25	28.43	29.01

It is not possible to conclude, as in the case of the analysis utilizing the measure of performance, that there exists no relationship between the effect upon drive level of varying quantities of reinforcement and the intelligence level of the subjects, for the subjects of high intelligence exhibited a significantly lower adjusted drive level under 100% reinforcement than the subjects of medium and low intelligence. No such differential effects upon the drive level of subjects of differing intelligence levels were observed in the case of the various partial reinforcement schedules, or in the case of the 0% reinforcement (or control) group.

It remains to examine the correspondence between these results and the corresponding results obtained when the dependent variable was pupil performance, as measured by the number of correct responses per trial. Table 14 enables the reader to compare the results of the two sets of analyses for differences between the subgroups of varying intelligence levels within the various reinforcement groups.

Clearly, with the single exception of the 100% reinforcement group, which has already been discussed, there is no marked divergence between the results for the two different dependent variables. Nevertheless, there is one important difference in the raw data which should be borne in mind when the correspondence between the two sets of results is considered.

The mean number of correct responses per trial for the low intelligence subgroup invariably lagged far behind the corresponding figure for the high intelligence subgroup, and usually considerably behind that for the medium intelligence subgroup. With respect to the mean gross number of responses, however, the low intelligence subgroup was invariably at least

on the same level as the high and medium intelligence subgroups. These means are presented in Tables 5, 7, 9, 11, and 13 in the present report and in Tables 3, 5, 7, 9, and 11 in the report dealing with performance as the dependent variable.

TABLE 14. RESULTS OF COVARIANCE ANALYSES FOR DIFFERENCES IN PERFORMANCE AND DRIVE LEVEL, RESPECTIVELY, BETWEEN SUBGROUPS OF DIFFERING INTELLIGENCE LEVELS WITHIN THE VARIOUS MASSED REINFORCEMENT GROUPS

Group	Degrees of freedom		Performance F	Drive level F
	Between groups	Within groups		
100%	2	61	0.29	3.62*
75%	2	70	0.06	0.57
50%	2	59	0.04	0.16
25%	2	64	2.45	0.86
0%	2	51	0.08	0.55

*Significant at the 0.05 level of confidence.

The Pattern of Verbal Reinforcement

The pattern of a fixed quantity of verbal reinforcement is defined as the sequence of reinforced and unreinforced trials. In the present studies, each quantity of partial reinforcement is investigated under two distinct patterns: a periodic pattern and a predetermined random pattern. An analysis of covariance was computed for each of the three partial reinforcement groups, to test for differences in drive level between these two subgroups.

The analysis for the 75% reinforcement group is summarized in Table 15. The obtained value of F was 5.58, which is significant at the 0.05 level of confidence for 1 degree of freedom between groups and 71 degrees of freedom within groups.

Inspection of Table 16, which presents the pretest, experimental, and adjusted means for the groups compared in the foregoing analysis, shows that, though the pretest means for the groups receiving periodic and random reinforcement were substantially the same, the experimental mean, and hence the adjusted mean, for the group receiving periodic reinforcement was considerably higher than that for the group receiving random reinforcement.

TABLE 15. ANALYSIS OF COVARIANCE FOR DIFFERENCES IN DRIVE LEVEL BETWEEN THE GROUPS RECEIVING 75% MASSED REINFORCEMENT ON A PERIODIC AND ON A RANDOM SCHEDULE, RESPECTIVELY

Source of variation	d.f.	Sum of squares of adjusted scores	Mean square	F
Total	72	4,085.08		
Within groups	71	3,787.64	53.35	
Between adjusted means	1	297.44	297.44	5.58*

*Significant at the 0.05 level of confidence.

TABLE 16. PRETEST, EXPERIMENTAL, AND ADJUSTED MEANS FOR THE GROUPS RECEIVING 75% MASSED REINFORCEMENT ON A PERIODIC AND ON A RANDOM SCHEDULE, RESPECTIVELY

Group*	n	Pretest mean	Experimental mean	Adjusted mean
75% P	34	24.97	33.09	33.41
75% R	40	25.55	29.67	29.39

*75% P denotes the group receiving 75% reinforcement on a periodic schedule, while 75% R denotes the group receiving the same amount of reinforcement on a random schedule. This notation is to be similarly interpreted in all succeeding tables.

A similar analysis of covariance was computed for differences between the groups receiving 50% verbal reinforcement on a periodic and on a random schedule, respectively. Inspection of Table 17, which summarizes the results of this analysis, shows that the observed difference is significant at the 0.01 level of confidence ($F = 8.89$).

Inspection of the table of adjusted means for the two 50% reinforcement groups (Table 18), indicates that the adjusted measure of drive level for the group reinforced on a random schedule was substantially above that for the group reinforced on a periodic schedule. In interpreting these results, however, the reader is referred to the note at the beginning of this chapter dealing with the observed procedures

in the case of the group receiving 50% reinforcement on a periodic schedule.

TABLE 17. ANALYSIS OF COVARIANCE FOR DIFFERENCES IN DRIVE LEVEL BETWEEN THE GROUPS RECEIVING 50% MASSED REINFORCEMENT ON A PERIODIC AND ON A RANDOM SCHEDULE, RESPECTIVELY

Source of variation	d.f.	Sum of squares of adjusted scores	Mean square	F
Total	61	1,656.31		
Within groups	60	1,442.49	24.04	
Between adjusted means	1	213.82	213.82	8.89*

*Significant at the 0.01 level of confidence.

TABLE 18. PRETEST, EXPERIMENTAL, AND ADJUSTED MEANS FOR THE GROUPS RECEIVING 50% MASSED REINFORCEMENT ON A PERIODIC AND ON A RANDOM SCHEDULE, RESPECTIVELY

Group	n	Pretest mean	Experimental mean	Adjusted mean
50% P	35	19.76	18.48	21.85
50% R	28	27.21	29.55	25.33

The results of a similar analysis of covariance for differences in drive level between the groups receiving 25% reinforcement on a periodic and on a random schedule, respectively, are summarized in Table 19. The obtained value of F was 1.52, which clearly falls short of statistical significance, with 1 degree of freedom between groups and 65 degrees of freedom within groups.

The pretest, experimental, and adjusted means for the groups compared in the foregoing analysis are presented in Table 20.

TABLE 19. ANALYSIS OF COVARIANCE FOR DIFFERENCES IN DRIVE LEVEL BETWEEN THE GROUPS RECEIVING 25% MASSED REINFORCEMENT ON A PERIODIC AND ON A RANDOM SCHEDULE, RESPECTIVELY

Source of variation	d.f.	Sum of squares of adjusted scores	Mean square	F
Total	66	2,564.64		
Within groups	65	2,506.18	38.56	
Between adjusted means	1	58.46	58.46	1.52

TABLE 20. PRETEST, EXPERIMENTAL, AND ADJUSTED MEANS FOR THE GROUPS RECEIVING 25% MASSED REINFORCEMENT ON A PERIODIC AND ON A RANDOM SCHEDULE, RESPECTIVELY

Group	n	Pretest mean	Experimental mean	Adjusted mean
25% P	36	18.96	21.32	20.88
25% R	32	17.37	18.54	19.03

That these results are in essential agreement with those obtained when a measure of performance was used as the dependent variable is easily seen from Table 21, which compares the results of the statistical analyses for the two dependent variables.

The Quantity of Verbal Reinforcement

The principal independent variable in the present experiment was the quantity of verbal reinforcement administered in the course of the 28 experimental trials. Two classrooms, of which one was reinforced on a periodic schedule and one on a random schedule, were assigned randomly to each of the 100%, 75%, 50%, 25%, and 0% reinforcement groups.

TABLE 21. RESULTS OF COVARIANCE ANALYSES FOR DIFFERENCES IN PERFORMANCE AND DRIVE LEVEL, RESPECTIVELY, BETWEEN THE GROUPS RECEIVING VARYING QUANTITIES OF MASSED PARTIAL VERBAL REINFORCEMENT ON PERIODIC AND RANDOM SCHEDULES

Group	Degrees of freedom		Performance		Drive level	
	Between groups	Within groups	F	Higher adjusted mean	F	Higher adjusted mean
75%	1	71	15.51*	Periodic	5.58*	Periodic
50%	1	60	3.41*	Random	8.89*	Random
25%	1	65	2.46**	Periodic	1.52	Periodic

*Significant at the 0.01 level of confidence.

*Significant at the 0.05 level of confidence.

*Significant at the 0.08 level of confidence.

**Significant at the 0.12 level of confidence.

To evaluate the effect of this independent variable upon the dependent variable of drive level, an analysis of covariance was computed for differences in mean gross number of responses per trial between the five different reinforcement groups. Table 22, which summarizes the results of this analysis, shows that the obtained value of F was 6.48, which is significant at the 0.01 level of confidence for 4 degrees of freedom between groups and 319 degrees of freedom within groups.

TABLE 22. ANALYSIS OF COVARIANCE FOR DIFFERENCES IN DRIVE LEVEL BETWEEN GROUPS RECEIVING VARYING QUANTITIES OF MASSED VERBAL REINFORCEMENT (PERIODIC AND RANDOM SCHEDULES POOLED)

Source of variation	d.f.	Sum of squares of adjusted scores	Mean square	F
Total	323	25,878.91		
Within groups	319	23,935.52	75.03	
Between adjusted means	4	1,943.39	485.85	6.48*

*Significant at the 0.01 level of confidence.

Table 23, which presents the pretest, experimental, and adjusted means for the five reinforcement groups, shows that the highest adjusted mean is that for the 75% reinforcement group. This is followed by the means for the 100%, 0%, 25%, and 50% groups, in that order. Except for the transposition of the 0% and 25% reinforcement groups, the same order of adjusted means was found to hold when the measure of the dependent variable was the number of correct responses per trial.

TABLE 23. PRETEST, EXPERIMENTAL, AND ADJUSTED MEANS FOR THE GROUPS RECEIVING VARYING QUANTITIES OF MASSED VERBAL REINFORCEMENT (PERIODIC AND RANDOM REINFORCEMENT GROUPS POOLED)

Group	n	Pretest mean	Experimental mean	Adjusted mean
100%	65	28.75	30.65	27.65
75%	74	25.28	31.24	30.69
50%	63	23.07	23.40	24.40
25%	68	18.21	20.01	24.44
0%	55	27.82	29.28	26.94

It is not clear from mere inspection of Tables 22 and 23 which of the adjusted means for the five reinforcement groups differed from each other significantly. Therefore the adjusted means for these groups were compared pairwise by means of the t-test for the analysis of covariance, as described by Cochran and Cox (7). Since the number of degrees of freedom within groups was sufficiently large, the approximation for the standard error of the difference between two adjusted means proposed by Finney (8) was employed to facilitate the analysis.

The results of these t-tests are presented in Table 24. It is clear that the adjusted mean for the 75% group is significantly higher than the means for all other reinforcement groups, while the adjusted mean for the 100% group is significantly higher than those for the 50% and 25% groups, but not significantly higher than that for the 0% (control) group. The adjusted means for the 50%, 25%, and 0% reinforcement groups do not differ from each other significantly.

The various significant differences in drive level due to variations in the pattern of reinforcement suggest that the foregoing analysis should be performed separately for groups receiving verbal reinforcement on a periodic schedule and for groups receiving reinforcement on a random schedule. Table 25 summarizes the results of this analysis for groups reinforced according to periodic schedules. The obtained F-value of 7.31

is significant at the 0.01 level of confidence for 4 degrees of freedom between groups and 219 degrees of freedom within groups.

TABLE 24. THE t-TESTS FOR DIFFERENCES BETWEEN THE ADJUSTED MEANS FOR THE GROUPS RECEIVING 100%, 75%, 50%, 25%, AND 0% MASSED VERBAL REINFORCEMENT

Group	75%	50%	25%	0%
100%	2.04*	2.11*	2.12*	0.45
75%		4.20*	4.25*	2.41*
50%			0.03	1.57
25%				1.58

*Significant at the 0.01 level of confidence.

*Significant at the 0.05 level of confidence.

TABLE 25. ANALYSIS OF COVARIANCE FOR DIFFERENCES IN DRIVE LEVEL BETWEEN GROUPS RECEIVING VARYING QUANTITIES OF MASSED REINFORCEMENT ON PERIODIC SCHEDULES

Source of variation	d.f.	Sum of squares of adjusted scores	Mean square	F
Total	223	20,720.91		
Within groups	219	18,278.99	83.47	
Between adjusted means	4	2,441.92	610.48	7.31*

*Significant at the 0.01 level of confidence.

Inspection of the table of pretest, experimental, and adjusted means for the groups reinforced on periodic schedules (Table 26) shows that the order by magnitude of the adjusted means is the same as in the case when periodically and randomly reinforced groups were pooled. Nevertheless, the t-tests between all pairs of adjusted means (Table 27) disclose one additional significant difference--between the 50% group and the 25% group. On the other hand, the adjusted mean for the 100% group is not significantly greater than that for the 25% group.

TABLE 26. PRETEST, EXPERIMENTAL, AND ADJUSTED MEANS FOR THE GROUPS RECEIVING VARYING QUANTITIES OF MASSED REINFORCEMENT ON PERIODIC SCHEDULES

Group	n	Pretest mean	Experimental mean	Adjusted mean
100%	65	28.75	30.65	28.22
75%	34	24.97	33.09	33.10
50%	35	19.76	18.48	21.86
25%	36	18.96	21.32	25.22
0%	55	27.82	29.28	27.45

TABLE 27. THE t-TESTS FOR DIFFERENCES BETWEEN THE ADJUSTED MEANS FOR THE GROUPS RECEIVING 100%, 75%, 50%, 25%, AND 0% MASSED REINFORCEMENT ON PERIODIC SCHEDULES

Group	75% P	50% P	25% P	0%
100%	2.50*	3.29**	1.57	0.46
75% P		5.07**	3.58**	2.81**
50% P			1.53	2.80**
25% P				1.13

*Significant at the 0.01 level of confidence.

**Significant at the 0.05 level of confidence.

The covariance analysis for differences in drive level between groups receiving varying quantities of reinforcement on random schedules is summarized in Table 28. Though the obtained F-value of 2.07 is not significant at the 0.05 level for 4 and 214 degrees of freedom, application of the method described by Burke (6) shows that it is significant at the 0.08 level.

Inspection of the means presented in Table 29 shows that the adjusted mean for the 25% group is substantially lower than the means for all other groups. The t-tests between all pairs of adjusted means (Table 30) indicate that the adjusted means for the 100%, 75%, 50%, and 0% groups are, in fact, all significantly (at least at the 0.10 level) higher than the adjusted mean for the 25% reinforcement group. There are no other significant differences between adjusted means.

TABLE 28. ANALYSIS OF COVARIANCE FOR DIFFERENCES IN DRIVE LEVEL BETWEEN GROUPS RECEIVING VARYING QUANTITIES OF MASSED REINFORCEMENT ON RANDOM SCHEDULES

Source of variation	d.f.	Sum of squares of adjusted scores	Mean square	F
Total	218	18,703.23		
Within groups	214	18,006.61	84.14	
Between adjusted means	4	696.62	174.16	2.07*

*Significant at the 0.08 level of confidence.

TABLE 29. PRETEST, EXPERIMENTAL, AND ADJUSTED MEANS FOR THE GROUPS RECEIVING VARYING QUANTITIES OF MASSED REINFORCEMENT ON RANDOM SCHEDULES

Group	n	Pretest mean	Experimental mean	Adjusted mean
100%	65	28.75	30.65	27.66
75% R	40	25.55	29.67	30.02
50% R	28	27.21	29.54	28.80
25% R	32	17.37	18.54	24.26
0%	55	27.82	29.28	28.14

TABLE 30. THE t-TESTS FOR DIFFERENCES BETWEEN THE ADJUSTED MEANS FOR THE GROUPS RECEIVING 100%, 75%, 50%, 25%, AND 0% MASSED REINFORCEMENT ON RANDOM SCHEDULES

Group	75% R	50% R	25% R	0%
100%	1.27	0.55	1.71⁑	0.29
75% R		0.54	2.63*	0.98
50% R			1.90*	0.31
25% R				1.89*

*Significant at the 0.05 level of confidence.

⁑Significant at the 0.10 level of confidence.

The correspondence between the foregoing results and the results obtained when the measure of the dependent variable was the number of correct responses per trial is exhibited in Table 31. Although divergences do appear between the results of the pairwise comparisons between groups in the two cases (see Table 20 in the earlier report already cited), the only essential difference between the general results is seen to occur in the case of the groups reinforced on random schedules, and that hinges only upon the low adjusted mean drive level displayed by the 25% periodic reinforcement group.

TABLE 31. RESULTS OF COVARIANCE ANALYSES FOR DIFFERENCES IN PERFORMANCE AND DRIVE LEVEL, RESPECTIVELY, BETWEEN THE GROUPS RECEIVING VARYING QUANTITIES OF MASSED VERBAL REINFORCEMENT

Groups	Degrees of freedom		Performance F	Drive level F
	Between groups	Within groups		
Periodic and random pooled	4	319	4.10*	6.48*
Periodic only	4	219	7.83*	7.31*
Random only	4	214	0.57	2.07*.

*Significant at the 0.01 level of confidence.

*.Significant at the 0.08 level of confidence.

Summary

Three hundred and twenty-five subjects, drawn from five third grade and five fourth grade classrooms, were tested on a routine arithmetical task for three pretest and 28 massed experimental trials. Two classes received each of the following quantities of reinforcement: 100%, 75%, 50%, 25%, and 0%; of each pair of classes, one was reinforced on a fixed periodic schedule and the other on a predetermined random schedule. Subjects in each group were classified into high, medium, and low intelligence subgroups. The dependent variable was defined to be drive level, as measured by the mean gross number of responses (correct and incorrect) per trial.

Analyses of covariance for differences in drive level between the subgroups of differing intelligence levels within each reinforcement group indicate that subjects of high intelligence fall significantly below subjects of medium and low intelligence in drive level under 100% reinforcement. Otherwise, a fixed quantity of reinforcement (including 0%) fails

to produce differential effects upon the drive level of subjects of varying intelligence levels.

Similar analyses for differences in drive level between groups receiving the same quantity of reinforcement on periodic and random schedules, respectively, resulted in F-values significant at the 0.01 level of confidence in the case of the 75% and 50% reinforcement groups, but not of the 25% group. It is not at all clear from these results which pattern of reinforcement results in the higher drive level.

An analysis of covariance for differences in drive level between groups receiving varying quantities of massed verbal reinforcement resulted in an F-value significant at the 0.01 level of confidence. The adjusted mean for the 75% reinforcement group was significantly higher than the means for all other groups, while the 100% group exhibited an adjusted mean significantly higher than those for the 50% and 25% reinforcement groups.

A separate analysis also yielded an F-value significant at the 0.01 level for the differences between groups reinforced on periodic schedules. The pairwise differences between reinforcement groups were also essentially the same as in the case when periodically and randomly reinforced groups were pooled.

The analysis for differences in drive level between groups reinforced on random schedules yielded an F-value significant at the 0.08 level of confidence. The t-tests between adjusted means showed that the means for all other reinforcement groups were significantly higher than the adjusted mean for the 25% group.

A fairly close correspondence was exhibited between the foregoing results and the results obtained when the dependent variable was taken to be performance, as measured by the number of correct responses per trial. The two major divergences were that the analyses utilizing performance did not exhibit differences in the dependent variable either between subgroups of varying intelligence levels within the 100% reinforcement group or between groups receiving varying quantities of verbal reinforcement on random schedules. Both of these differences appeared in the analysis when drive level was taken as the dependent variable.

CHAPTER IV

EXPERIMENT TWO: SPACED PRACTICE

Verbal Reinforcement and Intelligence

The second experiment differed from the first only in that the intertrial interval was not less than 24 hours. Therefore the analysis of the data is in all respects parallel to the analysis of the data of the first experiment.

The analysis of covariance for differences in drive level between the subgroups of high, medium, and low intelligence levels within the 100% reinforcement group is summarized in Table 32. The obtained F-value of 5.06 is significant at the 0.01 level of confidence for 2 degrees of freedom between groups and 46 degrees of freedom within groups. This result is sharply at variance with that obtained when performance was used as the dependent variable and the differences between subgroups were found to be statistically insignificant, but it is apparently in agreement with the result of the corresponding analysis in the experiment utilizing massed practice.

TABLE 32. ANALYSIS OF COVARIANCE FOR DIFFERENCES IN DRIVE LEVEL BETWEEN SUBGROUPS OF VARYING INTELLIGENCE LEVELS WITHIN THE 100% SPACED REINFORCEMENT GROUP

Source of variation	d.f.	Sum of squares of adjusted scores	Mean square	F
Total	48	2,478.28		
Within groups	46	2,031.74	44.17	
Between adjusted means	2	446.54	223.27	5.06*

*Significant at the 0.01 level of confidence.

Inspection of the adjusted means, in Table 33, however, indicates that in the present case the adjusted measure of drive level for the high and medium intelligence subgroups is significantly higher than that for the low intelligence subgroup. Under massed practice, it will be recalled, the adjusted measure of drive level for the high intelligence subgroup was significantly lower than that for the medium and low intelligence subgroups. In the present case, moreover,

the pretest and unadjusted experimental means for the low intelligence subgroup were substantially below those for the high intelligence subgroup (with the means for the medium intelligence subgroup roughly midway between them).

TABLE 33. PRETEST, EXPERIMENTAL, AND ADJUSTED MEANS FOR THE SUBGROUPS OF VARYING INTELLIGENCE LEVELS WITHIN THE 100% SPACED REINFORCEMENT GROUP

Intelligence level	n	Pretest mean	Experimental mean	Adjusted mean
High	13	25.72	41.76	34.96
Medium	26	20.17	31.93	32.34
Low	11	15.06	19.91	26.96

Table 34 summarizes the results of the analysis of covariance for differences in drive level between the subgroups of high, medium, and low intelligence within the 75% reinforcement group. The obtained F-value of 0.59 indicates that the differences between the subgroups are not statistically significant.

TABLE 34. ANALYSIS OF COVARIANCE FOR DIFFERENCES IN DRIVE LEVEL BETWEEN SUBGROUPS OF VARYING INTELLIGENCE LEVELS WITHIN THE 75% SPACED REINFORCEMENT GROUP

Source of variation	d.f.	Sum of squares of adjusted scores	Mean square	F
Total	59	4,442.08		
Within groups	57	4,351.99	76.35	
Between adjusted means	2	90.09	45.05	0.59

The pretest, experimental, and adjusted means associated with the foregoing analysis are presented in Table 35. It will be noted that, as in the case of the data obtained under massed practice, the pretest and unadjusted experimental means for the low intelligence subgroup are approximately on the same level as the means for the high and medium intelligence subgroups. In this respect the measure of drive level appears to behave differently than the measure of performance.

TABLE 35. PRETEST, EXPERIMENTAL, AND ADJUSTED MEANS FOR THE SUBGROUPS OF VARYING INTELLIGENCE LEVELS WITHIN THE 75% SPACED REINFORCEMENT GROUP

Intelligence level	n	Pretest mean	Experimental mean	Adjusted mean
High	9	28.19	39.66	37.35
Medium	29	25.98	39.00	39.22
Low	23	25.64	40.30	40.92

The analysis of covariance for differences in drive level between the subgroups of varying intelligence levels within the 50% reinforcement group is summarized in Table 36. The obtained F-value of 0.84 clearly indicates that the differences between subgroups in adjusted drive level are not statistically significant.

TABLE 36. ANALYSIS OF COVARIANCE FOR DIFFERENCES IN DRIVE LEVEL BETWEEN SUBGROUPS OF VARYING INTELLIGENCE LEVELS WITHIN THE 50% SPACED REINFORCEMENT GROUP

Source of variation	d.f.	Sum of squares of adjusted scores	Mean square	F
Total	50	3,407.13		
Within groups	48	3,292.10	68.59	
Between adjusted means	2	115.03	57.52	0.84

The pretest, experimental, and adjusted means associated with the foregoing analysis are presented in Table 37. It will be noted that the pretest and unadjusted experimental means for the high intelligence subgroup are considerably higher than the corresponding means for the other two subgroups.

The analysis of covariance for differences in drive level between the high, medium, and low intelligence subgroups of the 25% reinforcement group is summarized in Table 38. Clearly, the differences between the adjusted means of the subgroups (Table 39) are not statistically significant.

TABLE 37. PRETEST, EXPERIMENTAL, AND ADJUSTED MEANS FOR THE SUBGROUPS OF VARYING INTELLIGENCE LEVELS WITHIN THE 50% SPACED REINFORCEMENT GROUP

Intelligence level	n	Pretest mean	Experimental mean	Adjusted mean
High	15	29.16	46.63	38.01
Medium	28	20.52	32.52	35.12
Low	9	17.67	28.51	34.82

TABLE 38. ANALYSIS OF COVARIANCE FOR DIFFERENCES IN DRIVE LEVEL BETWEEN SUBGROUPS OF VARYING INTELLIGENCE LEVELS WITHIN THE 25% SPACED REINFORCEMENT GROUP

Source of variation	d.f.	Sum of squares of adjusted scores	Mean square	F
Total	53	4,677.47		
Within groups	51	4,423.68	86.74	
Between adjusted means	2	253.79	126.90	1.46

TABLE 39. PRETEST, EXPERIMENTAL, AND ADJUSTED MEANS FOR THE SUBGROUPS OF VARYING INTELLIGENCE LEVELS WITHIN THE 25% SPACED REINFORCEMENT GROUP

Intelligence level	n	Pretest mean	Experimental mean	Adjusted mean
High	7	16.76	31.55	32.05
Medium	25	16.40	28.75	29.55
Low	23	18.65	27.09	26.06

The result of the analysis of covariance, summarized in Table 40, for differences in drive level between the subgroups of differing intelligence levels within the 0% reinforcement group also indicates that there are no significant differences in drive level between these subgroups.

The pretest, experimental, and adjusted means associated with the foregoing analysis are presented in Table 41.

TABLE 40. ANALYSIS OF COVARIANCE FOR DIFFERENCES IN DRIVE LEVEL BETWEEN SUBGROUPS OF VARYING INTELLIGENCE LEVELS WITHIN THE 0% SPACED REINFORCEMENT GROUP

Source of variation	d.f.	Sum of squares of adjusted scores	Mean square	F
Total	64	3,578.29		
Within groups	62	3,485.61	56.22	
Between adjusted means	2	92.68	46.34	0.82

TABLE 41. PRETEST, EXPERIMENTAL, AND ADJUSTED MEANS FOR THE SUBGROUPS OF VARYING INTELLIGENCE LEVELS WITHIN THE 0% SPACED REINFORCEMENT GROUP

Intelligence level	n	Pretest Mean	Experimental mean	Adjusted mean
High	24	21.13	31.82	30.22
Medium	37	18.87	31.71	32.62
Low	5	18.80	29.43	30.41

The summary of statistical results in Table 42 will facilitate comparison of the foregoing results with the results obtained when the dependent variable was performance, as measured by the number of correct responses per trial.

TABLE 42. RESULTS OF COVARIANCE ANALYSES FOR DIFFERENCES IN DRIVE LEVEL AND PERFORMANCE, RESPECTIVELY, BETWEEN THE SUBGROUPS OF DIFFERING INTELLIGENCE LEVELS OF THE GROUPS RECEIVING VARYING QUANTITIES OF SPACED REINFORCEMENT

Group	Degrees of freedom		Performance F	Drive level F
	Between groups	Within groups		
100%	2	46	0.85	5.06*
75%	2	57	1.74	0.59
50%	2	48	0.37	0.84
25%	2	51	0.31	1.46
0%	2	62	0.37	0.82

*Significant at the 0.01 level of confidence.

It is clear that the correspondence between the two sets of results is fairly close, and it appears at first glance that the only divergence between them is identical to the divergence observed between the two sets of results for the experiment utilizing massed practice. It will be recalled, however, that the adjusted experimental mean for the high intelligence subgroup of the 100% massed reinforcement group was significantly lower than the adjusted means for the other two subgroups. In the case of the 100% spaced reinforcement group, the adjusted mean for the low intelligence subgroup was significantly lower than the means for the other two subgroups.

The Pattern of Verbal Reinforcement

To determine whether cyclic and predetermined random patterns of partial reinforcement exerted differential effects upon drive level on the routine arithmetical task utilized in these experiments, analyses of covariance were computed for differences in drive level between the periodically and randomly reinforced subgroups of each partial reinforcement group.

The results of this analysis for the 75% reinforcement group are summarized in Table 43, while the pretest, experimental, and adjusted means are presented in Table 44. It is clear from these tables that the adjusted measure of drive level is almost identical for the groups of subjects receiving 75% reinforcement on periodic and random schedules.

TABLE 43. ANALYSIS OF COVARIANCE FOR DIFFERENCES IN DRIVE LEVEL BETWEEN THE GROUPS RECEIVING 75% SPACED REINFORCEMENT ON A PERIODIC AND ON A RANDOM SCHEDULE, RESPECTIVELY

Source of variation	d.f.	Sum of squares of adjusted scores	Mean square	F
Total	59	4,442.08		
Within groups	58	4,441.88	76.58	
Between adjusted means	1	0.20	0.20	0

Table 45 summarizes the results of a similar analysis of covariance for differences in drive level between the subgroups of the 50% reinforcement group reinforced on a periodic and on a random schedule, respectively. The obtained F-value of 0.08 indicates that no significant differences exist.

TABLE 44. PRETEST, EXPERIMENTAL, AND ADJUSTED MEANS FOR THE GROUPS RECEIVING 75% SPACED REINFORCEMENT ON A PERIODIC AND ON A RANDOM SCHEDULE, RESPECTIVELY

Group	n	Pretest mean	Experimental mean	Adjusted mean
75% P	32	24.65	37.78	39.53
75% R	29	27.86	41.58	39.64

TABLE 45. ANALYSIS OF COVARIANCE FOR DIFFERENCES IN DRIVE LEVEL BETWEEN THE GROUPS RECEIVING 50% SPACED REINFORCEMENT ON A PERIODIC AND ON A RANDOM SCHEDULE, RESPECTIVELY

Source of variation	d.f.	Sum of squares of adjusted scores	Mean square	F
Total	50	3,407.13		
Within groups	49	3,401.71	69.42	
Between adjusted means	1	5.42	5.42	0.08

Comparison of Table 46, which presents the pretest, experimental, and adjusted means associated with the foregoing analysis, with Table 1 indicates that the wide margin by which the pretest and experimental means for the randomly reinforced subgroup exceed those for the periodically reinforced subgroup may be explained by the fact that the former was a fourth-grade class, while the latter was a third-grade class.

TABLE 46. PRETEST, EXPERIMENTAL, AND ADJUSTED MEANS FOR THE GROUPS RECEIVING 50% SPACED REINFORCEMENT ON A PERIODIC AND ON A RANDOM SCHEDULE, RESPECTIVELY

Group	n	Pretest mean	Experimental mean	Adjusted mean
50% P	32	17.09	29.03	36.08
50% R	20	31.20	46.89	35.60

It must also be noted that the last two results diverge sharply from the two corresponding results obtained in the study utilizing massed practice (Tables 15 and 16, and 17 and 18, respectively), which showed a difference significant at the 0.05 level in favor of the group receiving 75% reinforcement on a periodic schedule and a difference significant at the 0.01 level in favor of the group receiving 50% reinforcement on a random schedule.

The results of the corresponding covariance analysis for the 25% reinforcement group, summarized in Table 47, indicate that there are no significant differences in drive level between the periodically and randomly reinforced subgroups of the 25% reinforcement group either. The pretest, experimental, and adjusted means associated with this analysis are presented in Table 48.

TABLE 47. ANALYSIS OF COVARIANCE FOR DIFFERENCES IN DRIVE LEVEL BETWEEN THE GROUPS RECEIVING 25% SPACED REINFORCEMENT ON A PERIODIC AND ON A RANDOM SCHEDULE, RESPECTIVELY

Source of variation	d.f.	Sum of squares of adjusted scores	Mean square	F
Total	53	4,677.47		
Within groups	52	4,602.36	88.51	
Between adjusted means	1	75.11	75.11	0.84

TABLE 48. PRETEST, EXPERIMENTAL, AND ADJUSTED MEANS FOR THE GROUPS RECEIVING 25% SPACED REINFORCEMENT ON A PERIODIC AND ON A RANDOM SCHEDULE, RESPECTIVELY

Group	n	Pretest mean	Experimental mean	Adjusted mean
25% P	24	20.25	32.02	29.70
25% R	31	15.17	25.61	27.41

Table 49 presents a comparison of the analytical results concerning the effects of the pattern of partial reinforcement on performance and drive level, respectively. The two sets of results agree only in exhibiting no differences under 75% reinforcement. Reference to Table 21 shows that

the agreement between the results for the two distinct dependent variables is much closer in the case of massed practice.

TABLE 49. RESULTS OF COVARIANCE ANALYSES FOR DIFFERENCES IN PERFORMANCE AND DRIVE LEVEL, RESPECTIVELY, BETWEEN GROUPS RECEIVING VARYING QUANTITIES OF SPACED PARTIAL REINFORCEMENT ON PERIODIC AND RANDOM SCHEDULES

Group	Degrees of freedom		Performance		Drive level	
	Between groups	Within groups	F	Higher adjusted mean	F	Higher adjusted mean
75%	1	58	0		0	
50%	1	49	11.63*	Periodic	0.08	Periodic
25%	1	52	10.97*	Random	0.84	Periodic

*Significant at the 0.01 level of confidence.

The Quantity of Verbal Reinforcement

Since the results presented in Tables 43 to 48 have established the absence of any significant differences in drive level between groups receiving a given quantity of partial reinforcement on varying schedules, the effect of varying quantities of reinforcement on drive level may be investigated for periodically reinforced, randomly reinforced, or pooled groups, and the obtained result extended to the other two categories.

Table 50 summarizes the results of an analysis of covariance for differences in drive level between groups receiving varying quantities of reinforcement. The subgroups receiving fixed quantities of partial reinforcement on differing schedules have been pooled. It is clear from the obtained F-value of 0.47 that no significant differences exist between the adjusted means (Table 51).

This result is sharply at variance not only with the corresponding result for the experiment utilizing massed practice ($F = 6.48$, $p < 0.01$), but also with the corresponding result under spaced practice when performance is taken as the dependent variable ($F = 4.71$, $p < 0.01$). In the latter case, differences significant at the same level of confidence were also found to exist when periodically and randomly reinforced groups were compared separately.

TABLE 50. ANALYSIS OF COVARIANCE FOR DIFFERENCES IN DRIVE LEVEL BETWEEN GROUPS RECEIVING VARYING QUANTITIES OF VERBAL REINFORCEMENT (PERIODIC AND RANDOM SCHEDULES POOLED)

Source of variation	d.f.	Sum of squares of adjusted scores	Mean square	F
Total	282	19,739.32		
Within groups	278	19,605.57	70.60	
Between adjusted means	4	133.75	33.44	0.47

TABLE 51. PRETEST, EXPERIMENTAL, AND ADJUSTED MEANS FOR THE GROUPS RECEIVING VARYING QUANTITIES OF VERBAL REINFORCEMENT (PERIODIC AND RANDOM REINFORCEMENT GROUPS POOLED)

Group	n	Pretest mean	Experimental mean	Adjusted mean
100%	50	20.49	31.84	32.75
75%	61	26.18	39.59	34.07
50%	52	22.52	35.90	34.51
25%	55	17.39	28.41	32.82
0%	66	19.68	31.58	33.40

Summary

Two hundred and eighty-four subjects, drawn from five third-grade and five fourth-grade classrooms, were tested on a routine arithmetical task for three pretest and 28 spaced experimental trials (intertrial interval: 24 hours). Two classes received each of the following quantities of reinforcement: 100%, 75%, 50%, 25%, and 0%; one of each pair of classes was reinforced on a fixed periodic schedule and the other was reinforced on a predetermined random schedule. Subjects in each group were classified into high, medium, and low intelligence subgroups. The dependent variable was defined to be drive level, as measured by the mean gross number of responses (correct and incorrect) per trial.

Although an analysis of covariance between subgroups of differing intelligence levels within the 100% reinforcement group revealed significant differences in drive level, no differences appeared between subgroups of any other reinforcement group.

Analyses of covariance for differences in drive level between groups receiving the same quantity of partial reinforcement on periodic and random schedules, respectively, resulted in F-values less than unity for all three partial reinforcement groups.

Significant differences in drive level were likewise absent between groups receiving varying quantities of verbal reinforcement, with periodically and randomly reinforced subgroups pooled. From the absence of differences between such subgroups, it may be concluded that the same result will hold for groups receiving varying quantities of periodic reinforcement only and for groups receiving varying quantities of random reinforcement only.

The absence of significant differences in drive level between groups receiving varying quantities of reinforcement under spaced practice and between subgroups reinforced under varying schedules represents a divergence from the corresponding results under massed practice. These same results also diverge markedly from the corresponding results obtained when performance was taken as the dependent variable.

CHAPTER V

CONCLUSIONS

The results of the statistical analysis of the relationship between quantity and pattern of verbal reinforcement under massed and spaced practice and pupil performance on a routine arithmetical task enabled the present authors to draw four major conclusions, which are reviewed here briefly.

First, a fixed quantity of verbal reinforcement fails to produce differential effects upon the performance of pupils of varying intelligence levels. Second, varying patterns of partial reinforcement do exert differential effects upon performance, though the data do not indicate clearly which of the two patterns investigated leads to superior performance. Third, varying quantities of verbal reinforcement lead to highly significant differences in performance on a routine arithmetical task, but an optimum quantity of reinforcement cannot be selected on the basis of the available data. Fourth, these conclusions are valid for verbal reinforcement administered both under massed practice and under spaced practice.

Before submitting the measure of drive to an exactly parallel analysis, the authors have shown that this measure is not uniformly dependent upon the measure of performance. The following conclusions can now be drawn from the results of this parallel analysis.

First, a fixed quantity of verbal reinforcement produces no differential effects on the drive level of pupils of varying intelligence levels, except under 100% reinforcement under both massed and spaced practice. As the order by magnitude of the adjusted means of the subgroups of varying intelligence levels within the 100% reinforcement group differs under the two different conditions investigated, no more specific conclusion can be drawn.

Second, varying patterns of partial reinforcement produce differential effects upon drive level when reinforcement is administered under massed practice, but they fail to do so under spaced practice.

Third, varying quantities of verbal reinforcement result in highly significant differences in drive level under massed practice, but no such differences appear under spaced practice.

It is clear that the close correspondence between the conclusions that can be drawn concerning the effects of verbal reinforcement under massed practice and under spaced practice when a measure of performance is used as the dependent variable can no longer be observed when a measure of drive is substituted for the measure of performance.

Comparing the results obtained for the two different dependent variables, one can see that, except for significant differences in drive level within the 100% reinforcement group, a fixed quantity of verbal reinforcement results in no differences in performance or drive level between subgroups of varying intelligence levels, regardless of the intertrial interval.

Varying patterns of verbal reinforcement under massed practice produce differential effects upon both performance and drive level, but under spaced practice such effects are observable only upon performance. In all cases the observed differences are not sufficiently systematic to permit any conclusion as to the pattern under which a fixed quantity of verbal reinforcement produces optimum effects.

Finally, varying quantities of verbal reinforcement under massed practice exert highly significant differential effects upon both performance and drive level, but no differential effects upon drive level can be observed when the reinforcement is administered under spaced practice. It must be pointed out that the only significant differences observed in performance under spaced practice were between the 75% reinforcement group (which had the lowest adjusted mean) and all other groups.

It is the opinion of the authors that this lack of clear-cut differences in both performance and drive between groups receiving varying quantities of reinforcement under spaced practice may be partially explained by the fact that the public school pupils who served as subjects were learning arithmetic from other sources than the experimental task throughout the eight weeks spanned by the experiment utilizing spaced practice. This difficulty can only be avoided by use of a routine task unrelated to curricular learning in such experiments.

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